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A PRELIMINARY STUDY OF AIRPLANE PERFORMANCE.

By F. H. Norton and W. G. Brown,
Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics.

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TECHNICAL NOTE NO. 120.

A PRELIMINARY STUDY OF AIRPLANE PERFORMANCE.

By F. H. Norton and W. G. Brown.

Summary.

Flight tests were carried out at the Langley Field laboratory of the National Advisory Committee for Aeronautics, on several airplanes for the purpose of determining their relative performance with the same engine and the same propeller. The method used consisted in flying each airplane on a level course and measuring the airspeed for the whole range of engine revolutions. In general the results show that a small change in the wing section or the wing area has but a slight effect upon the performance, but changes in those parts which cause the structural resistance have a very important effect.

Introduction.

The Committee has in commission three JN4h airplanes, all varying somewhat in the type of supporting surface used. It also has a VE-7 airplane having the same engine and about the same weight as the preceding airplanes, but much more carefully streamlined. In flying these airplanes it has been often observed that there is very little difference in the performance of the JN4h airplane whereas the VE-7 showed a distinctly higher performance

It was thought that a test to compare the performance of these four airplanes would be of considerable interest to designers, in order to show the great importance of careful streamlining. The following tests were therefore carried out:

1. JN4h #1 with JN propeller.
2. JN4h #1 with VE-7 propeller.
3. JN4h #2 with JN propeller.
4. JN4h #3 with JN propeller.
5. VE-7 with JN propeller.
6. VE-7 with VE-7 propeller.
7. VE-7 with S.E.5 propeller.

Airplanes.

Airplane #1 was a standard rigged JN4h as shown in Figs. 1 and 2. The wings were of the usual Eiffel 36 section as given in Report No. 70. The engine in this airplane was a Wright Model A attached to the usual JN4h propeller of 8.5 ft. diameter and 5.22 ft. pitch. The weight of the airplane ready to fly with crew and full tanks was about 2250 lbs., giving a wing loading of 6.4 lb. sq.ft.

Airplane #2 was similar in every way to the preceding one excepting that the wing section was the R.A.F.15, and the engine a Wright Model E. In these tests at low altitude however, the Model E engine may be considered equivalent to the Model A when the same propeller is used as the dimensions of the cylinders are the same and the torque developed by both engines is practically

identical at sea level. The total weight of the airplane and the wing loading was approximately the same as before.

Airplane #3 had the Model E engine and the Eiffel 36 section but the area was reduced by the use of two sets of lower wings to 300 sq.ft. or 50 sq.ft. less than the standard airplane. The king posts and overhang wires were also removed. The total weight of this airplane was about 2200 lbs., making the wing loading 7.3 lbs/sq.ft.

Model #4 was a standard Navy Vought as shown in Figs. 3 and 4. All wires were streamlined and the engine was a Model E. The total weight of the airplane ready to fly was 2050 lbs., giving a wing loading of 7.2 lbs/sq.ft.

Method of Test.

All of the runs were made at a constant height by the aid of a sensitive statoscope mounted on the pilot's instrument board. The average altitude for all of these tests was approximately 2000 ft. and all the speeds have been corrected for density and are therefore true speeds. The installation correction for the airspeed head mounted on the wing was determined for each airplane by the following method: A streamlined body with a pitot tube in the nose and a stabilizing tail was lowered from the airplane by means of a steel wire and two rubber tubes which connected the pitot and static opening to an airspeed dial on the observer's instrument board. The airplane was then run through the whole speed range and the difference between the readings of

the two pitot heads gave directly the installation error.

Precision.

The tachometers used in this test were all of the chronometric type and were carefully checked up before the runs were made so the readings should be correct to within 110 revolutions per minute. All of the airspeed instruments were calibrated in the laboratory against the water column before and after the tests so that the airspeed readings should be precise to within 11 mile per hour. A good deal of trouble was experienced by rising and falling currents during these tests making it necessary to check each run several times and even then the readings may be out by two miles an hour from this cause. It should be noted, however, that this test is simply a rather rough comparative one as more exact figures will be obtained later by glides with the propeller stopped and with means for eliminating the effects of vertical currents.

Results.

The results of all of the tests are plotted in Fig. 5 where the R.P.M. of the engine is plotted against true airspeeds of the airplane. It will be seen that the curves for the three JN4h's with the JN propeller are fairly close together with the standard airplane quite markedly the lowest as we should expect. The application of the Vought propeller to the #1 airplane gives a considerable increase in the propulsive efficiency, especially at the lower speeds.

Airplane #4 with the JN propeller stands out distinctly from the other airplanes with an airspeed for a given R.P.M. of 20 to 35 miles per hour higher. It will also be noted that this airplane can fly level at slightly over 1000 R.P.M., whereas the other airplanes require at least 1200 R.P.M., a very striking difference. When the VE-7 propeller is placed on airplane #4 a somewhat higher speed is obtained for the same R.P.M. up to 1550 R.P.M., which was the limiting speed with the JN propeller. The VE-7 propeller, however, allows the engine to turn up to 1700 R.P.M., thereby developing considerably more power and giving an airspeed of 126 miles an hour, which is 40 miles an hour faster than the maximum speed of the other airplanes. Another run was tried upon airplane #4 with an S.E.5 propeller. This propeller allowed the engine to turn up to 2100 R.P.M. but gave a speed of only 122 miles per hour.

In order to give an idea of the comparative drags of the four airplanes, the thrust of the propeller was computed for each (Fig. 6) by the method used in N.A.C.A. Report No. 70. As the JN propeller used here varied slightly from the one used in the tests referred to, the drags are only an approximation, but are satisfactory for comparison among themselves.

The drag of the JN4h's lie fairly close together, while the drag of the VE-7 is much lower. The minimum values of drag and maximum values of the L/D are given in the following table:

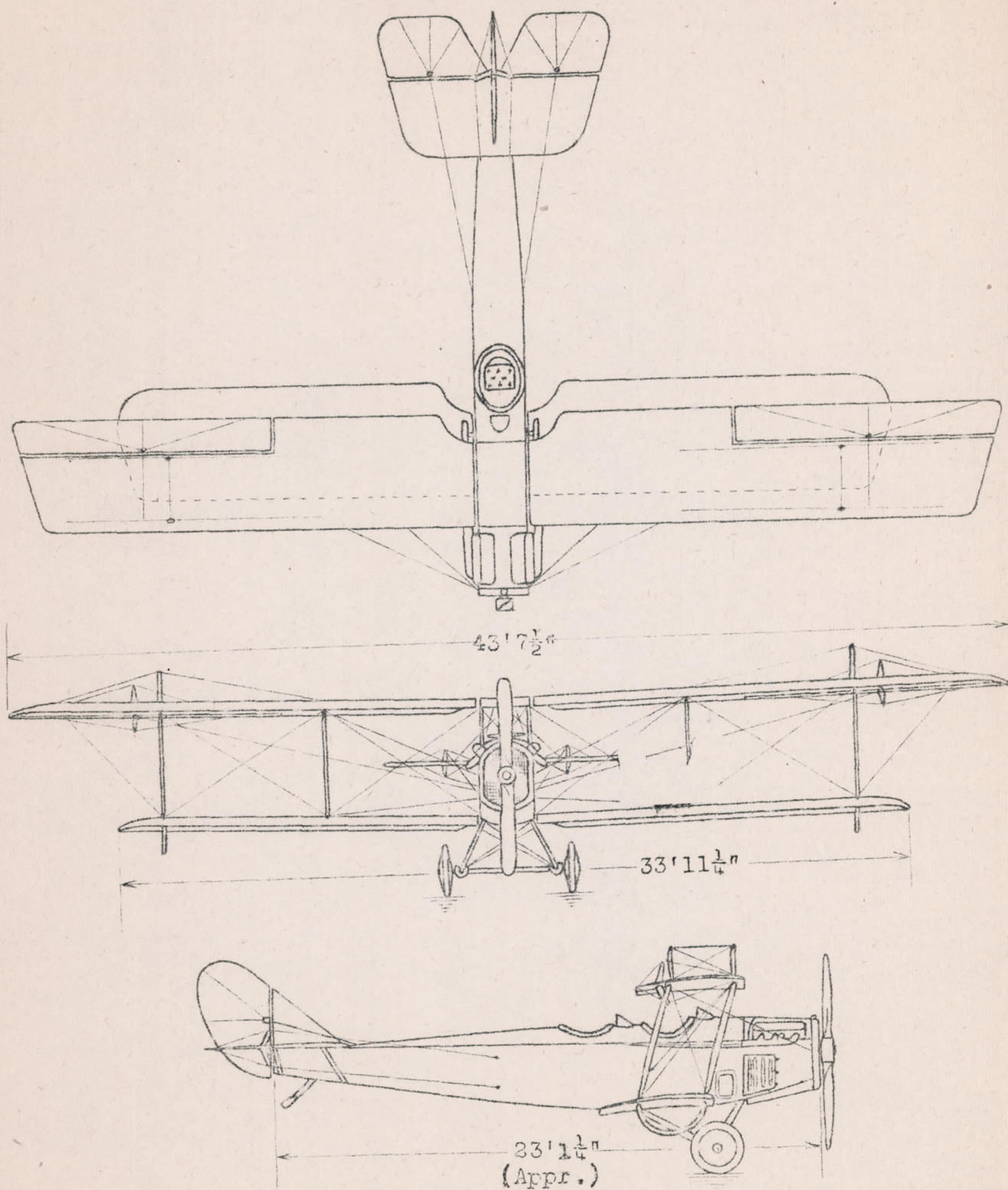
Airplane	Minimum Drag in pounds	Maximum L/D
JN4h #1	405	5.6
JN4h #2	340	6.6
JN4h #3	350	6.3
VE-7	195	10.5

What features of design account for the reduction in drag of the VE-7 to one-half of that for the others? It cannot be the wings, and tests have shown that the streamlined wires increase the maximum speed 5 M.P.H. Of course the concealed fittings reduce the drag to some extent, but certainly not more than the streamlined wires. As the landing gear and tail surface are practically the same for all of the airplanes, we are left only with the fuselage and radiator resistance - or their influence on the propeller efficiency - to account for this difference. The forward end of the VE-7 fuselage is well rounded and fairs in to a circular radiator, while the JN fuselage and radiator is larger and rectangular. It is hoped that time will be available in the near future to equip the VE-7 with a JN radiator and cowling. This should give the answer to our present problem.

Conclusions.

We may conclude from these tests that the use of high speed wing sections and a small reduction in wing area will increase

the speed of the airplane to only a slight extent. What is far more important from the standpoint of efficiency is the careful streamlining of all exposed parts, the encasing of all fittings inside of the wings or fuselage, and the fuselage and radiator combination which will give - in conjunction with the propeller - the highest overall efficiency. The fact is also brought out that great care should be used in adapting a propeller to a particular airplane in order to obtain the greatest overall performance.



JN4h

Fig.1

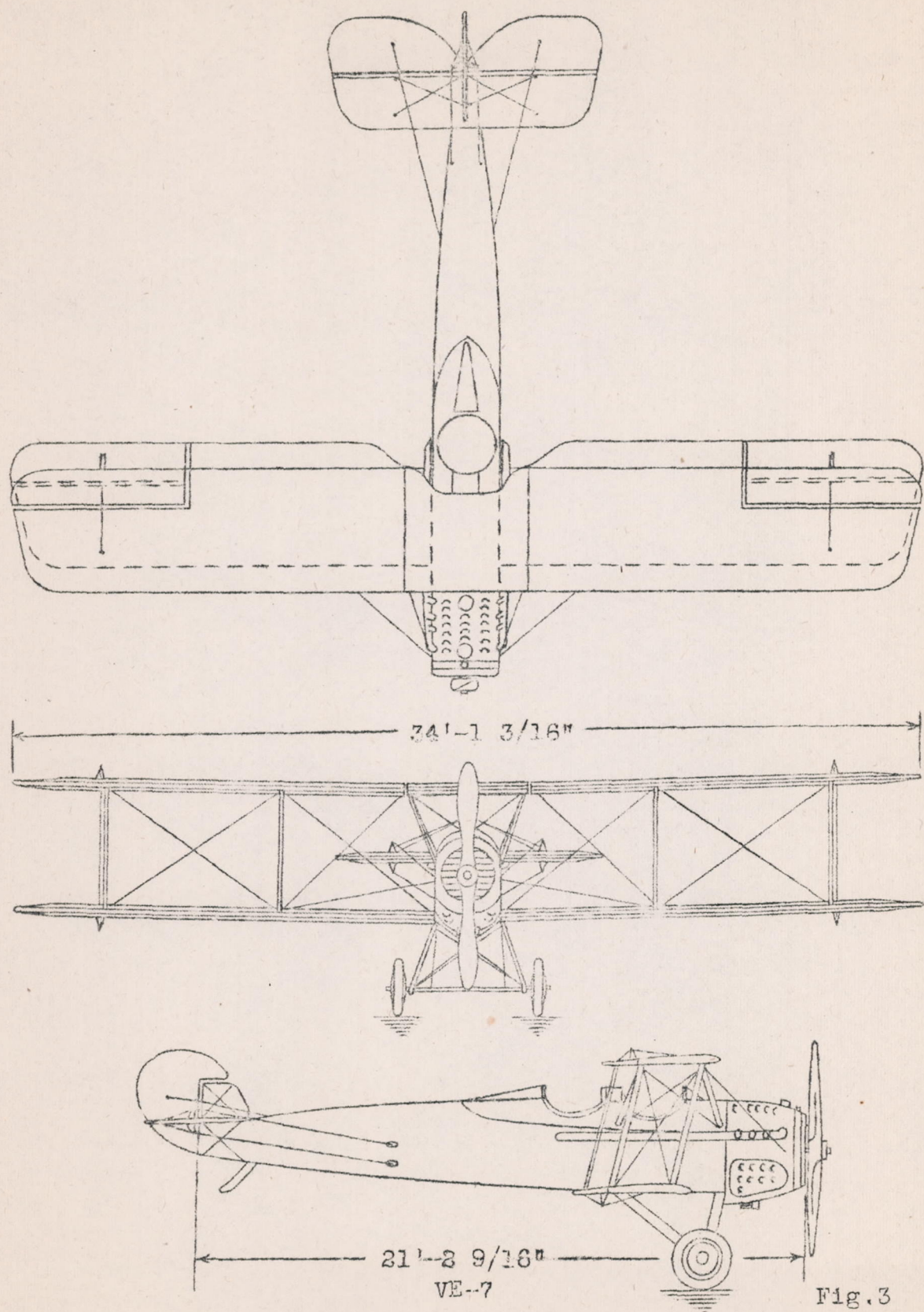


Fig. 3

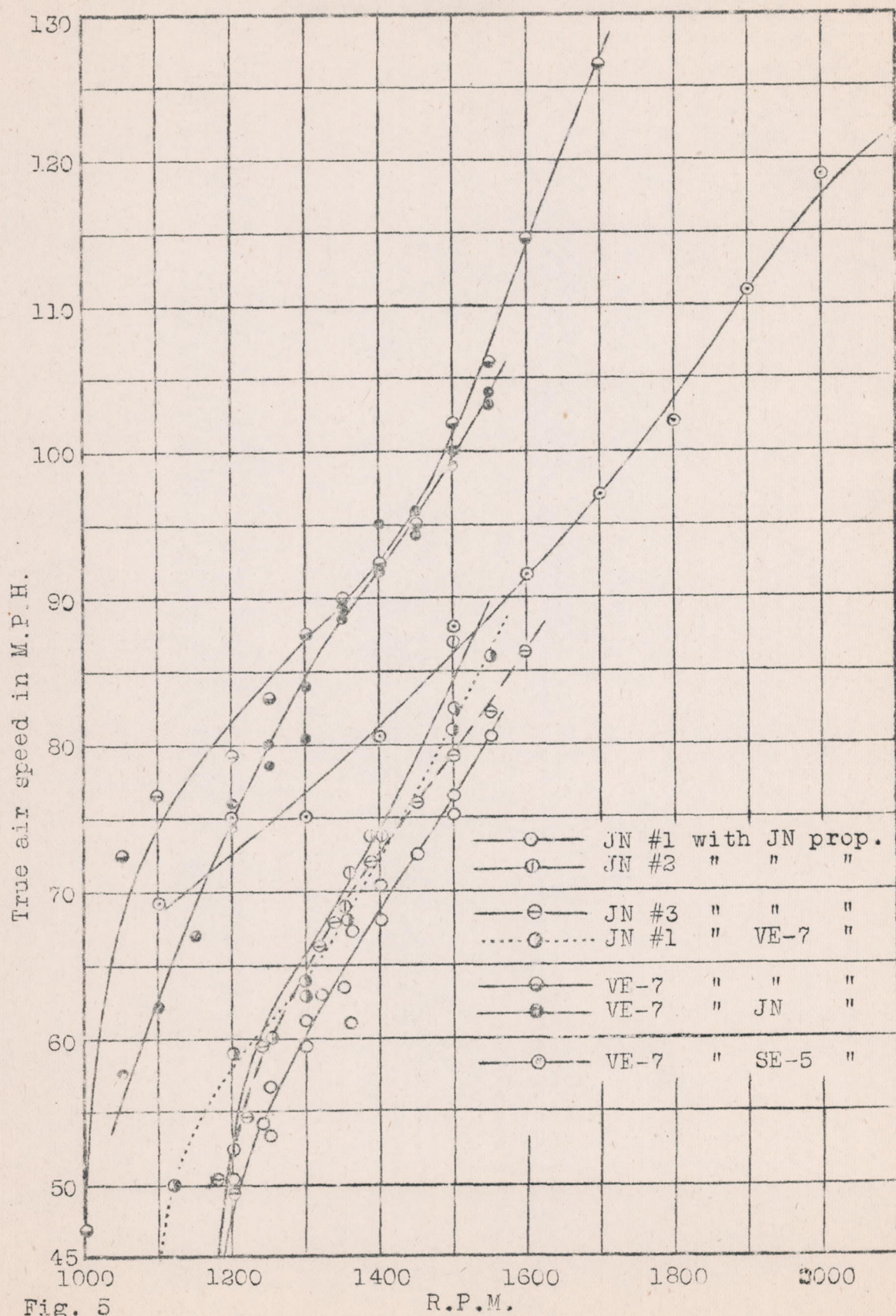


Fig. 5

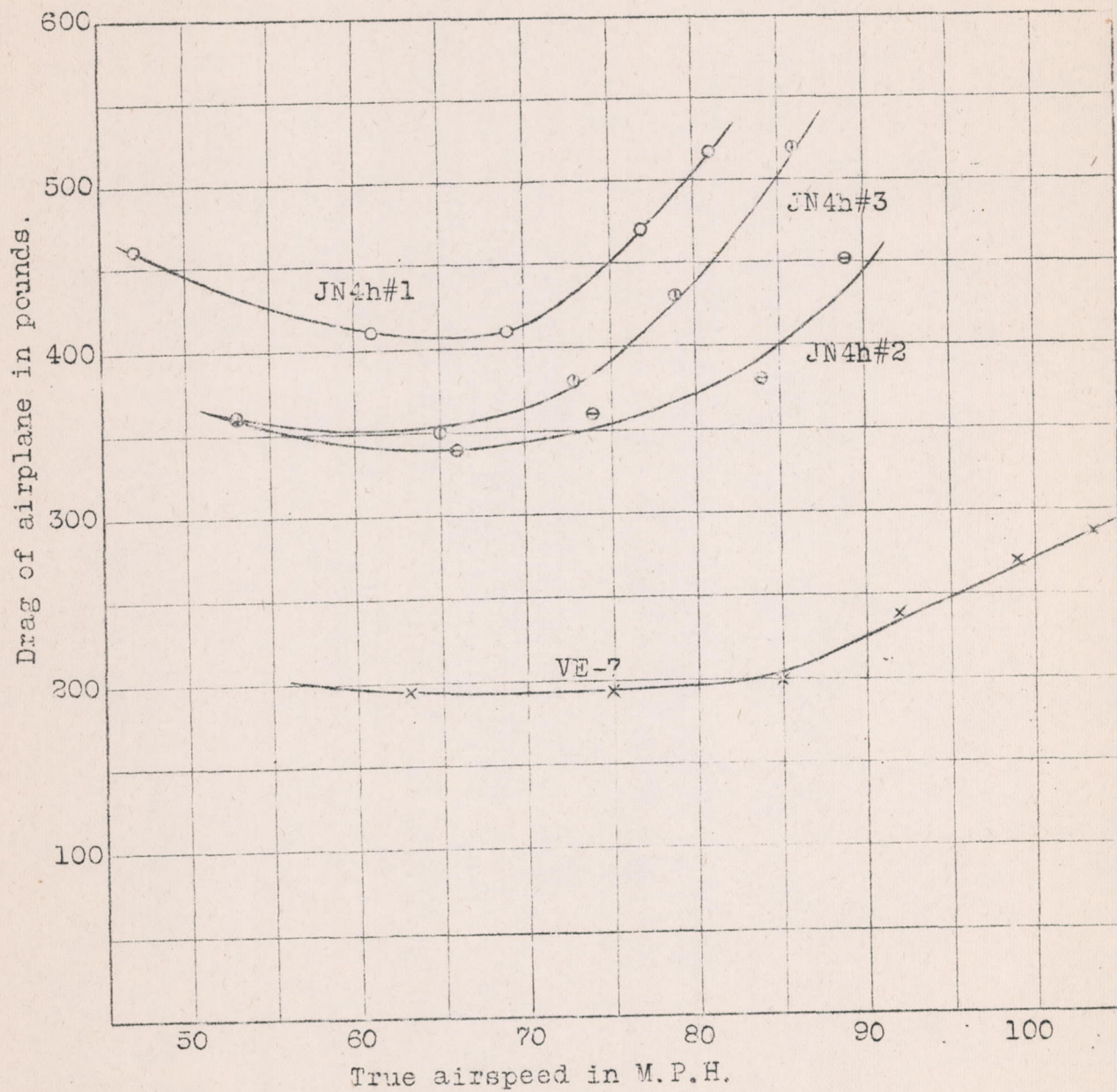


Fig. 6.



Fig. 2

JN4h



Fig. 4

VE-7